# UV/Visible Radiation Climate Variability on a Decadal Scale at Svalbard

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**Solar radiation is one of the most important parameters controlling biological activity in arctic marine ecosystems. The amount of visible light generally triggers the spring algae bloom which in turn is the starting point for higher-trophic level processes. On the other hand, the ultraviolet part of the radiation may have adverse effects on the ecosystem, especially during the growth period in spring. While visible radiation (e.g. PAR) data have been measured at Ny-Ålesund, Svalbard, for several decades, UV data are available for only about 10 years. However, by using existing ozone, cloud cover, albedo/snow cover and further ancillary data, e.g., aerosols, in a radiative transfer model (RTM), UV (and visible) radiation can be re-constructed.**

## Model Input Parameters

### Daily total ozone columns

| | |
|---|---|
| 1950-1966: | Dobson spectrometer Longyearbyen |
| 1967-1968, 1994-2005*: | Dobson spectrometer Ny-Ålesund |
| 1970-1977: | BUV satellite data |
| 1979-2001*: | TOMS satellite data |
| 1991-2005*: | SAOZ instrument Ny-Ålesund |
| 1995-2005*: | GUV filter instrument Ny-Ålesund |

* Overlapping measurements averaged on a daily basis

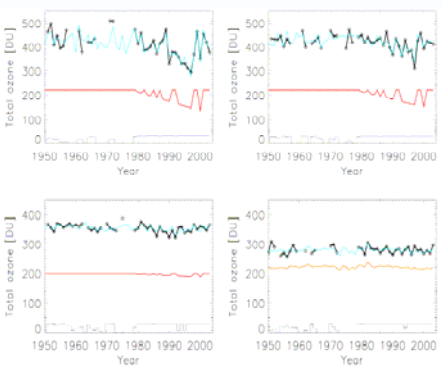


**Figure 1.**
Total ozone monthly means from Svalbard for March (upper left), April (upper right), June (lower left), and September (lower right), based on Dobson measure-ments (before 1970), BUV (1970-77), TOMS (most data after 1978), and contributions from other instruments (after 1990): black line. Light blue: multi-linear fit, using various parameters, including climate patterns. Derived modified linear trend since 1978: red line. Orange line (lower right): 30 mbar level T.

### Daily cloud cover observations

Observations once per day (12 LT) of cloud cover fraction (octals) from Hopen Island (1945-2006), Bear Island (1921-2006), and Ny-Ålesund (1974-2006), Svalbard.

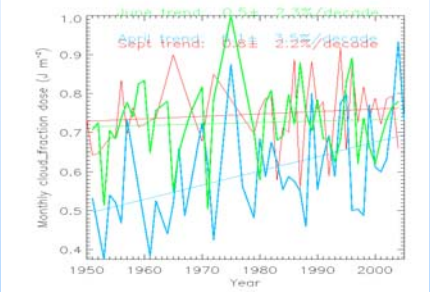


**Figure 2.**
April, June and September cloud cover fraction monthly average at Hopen Island, including trends. There has been no significant trend in June and September, but a highly significant positive trend in April (**6.1±3.5 % /decade**).

### Model

Radiative transfer modelling software package **libRadtran** (freely available on internet at www.libradtran.org )
Fixed input parameters (very similar to Skrova series [Engelsen et al., 2004]:
- Surface albedo:0.1 (ocean albedo at a wind speed of 7m/s)
- Aerosol load: parameterized by a visibility of 25 km (global average value)
- U.S. Standard Atmosphere

Cloud parameterisation:
$I_{UV,total} = (1\text{-}CF) \cdot I_{UV,clear} + CF \cdot I_{UV,overcast}$

$I_{UV,overcast}$: calculated with radiative transfer modelling assuming a typical cloud liquid water column at the observation site (determined empirically)

### Validation

Comparison of modelled daily doses based on cloud fraction octals and TOMS ozone data to measurements taken with the GUV multi-channel filter instrument during spring/ summer 1997 in Tromsø (see Engelsen et al., 2004):

**Good average agreement, but deviations of up to ±30% on a day-to-day basis:**
**noon observations not representative for all-day cloud coverage !**

## Results

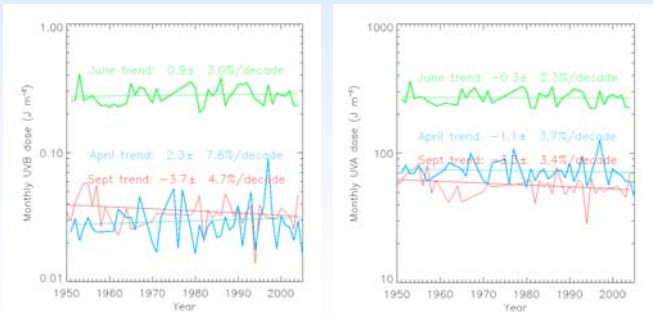


**Figure 3.**
Monthly doses of UV-B (left panel) and UV-A (right panel) for April, June and September at Hopen Island: no significant trends in all months analysed:

| | | |
|---|---|---|
| April: | +2.3 ± 7.8 % (UV-B) | -1.1 ± 3.7 % (UV-A) |
| June : | +0.9 ± 3.0 % | -0.3 ± 2.3 % |
| September: | - 3.7 ± 4.7 % | -3.3 ± 3.4 % (all values per decade) |

## For comparison:

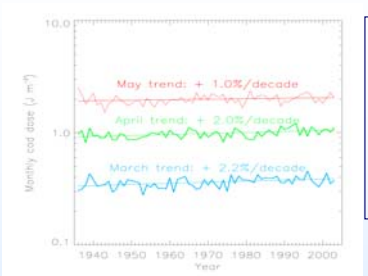


**Figure 4.**
Monthly doses of UV-B (cod egg action spectrum) for March, April and May at Skrova: positive trends (significant in March and April). Cloud coverage trends differing significantly from Hopen Island observations: no trends during the spring months, but periodicity in number of cloud-free days.

## (Preliminary) conclusions

- **Total ozone, one of the most dominant parameters influencing UV levels, shows seasonally highly variable long-term trend at Svalbard:significantly negative in spring since 1975, virtually no trend in summer and autumn.**
- **In contrast to N-Norway, cloud coverage has increased significantly at Hopen Island, in spring, thus counteracting the negative ozone trend at Svalbard in recent decades.**
- **In the 3 months investigated so far (April, June, September), no significant trends in UV-B and UV-A monthly mean doses have been found.**
- **The year 1997 with its prelonged stratospheric vortex and low ozone throughout April sticks out as the year with the clearly highest UV-B levels on a monthly average basis.**

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